R E P O R T R E S U M E S

ED 003 323 24

THE REINFORCING EFFECTS OF TWO TYPES OF CONFIRMATION IN PROGRAMMED INSTRUCTION.

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REPORT NUMBER CRP-2035 PUB DATE 64
EDRS PRICE MF-$0.09 HC-$1.96 49P.

DESCRIPTORS- *PROGRAMED INSTRUCTION, MOTIVATION, *STUDENT MOTIVATION, EVALUATION, *PROGRAM EVALUATION, *LEARNING PROCESSES, *TESTING, EXPERIMENTAL PROGRAMS, FEEDBACK, NEW YORK CITY, NEW YORK

A STUDY WAS CONDUCTED TO COMPARE THE EFFECTIVENESS OF TWO KINDS OF CONFIRMATION IN PROGRAMED INSTRUCTION--RESPONSE CONFIRMATION AND EXAMINATION FEEDBACK. EXPERIMENTAL CONDITIONS OF HIGH, MEDIUM, AND LOW STUDENT MOTIVATION AND HIGH AND LOW ERROR-RATE WERE UTILIZED. RESPONSE CONFIRMATION REFERS TO THE CONVENTIONAL METHOD OF CONFIRMING EACH ONE OF THE LEARNER'S RESPONSES IMMEDIATELY AFTER HE MAKES IT. EXAMINATION FEEDBACK REFERS TO THE METHOD OF GIVING THE LEARNER SELF-SCORING QUIZZES DURING THE PROGRAM AND CONFIRMING ONLY THE RESPONSES TO THEM. ALL OTHER RESPONSES ARE NOT CONFIRMED. THE STUDY WAS A 3X3X2 FACTORIAL DESIGN WITH HIGH, MEDIUM, AND LOW TASK MOTIVATION AS ONE DIMENSION, HIGH AND LOW ERROR RATE AS A SECOND DIMENSION, AND RESPONSE CONFIRMATION VERSUS EXAMINATION FEEDBACK AS A THIRD DIMENSION. THERE WERE 20 SUBJECTS ASSIGNED TO EACH OF THE 12 GROUPS ON THE BASIS OF RESPONSES TO A QUESTIONNAIRE ADMINISTERED PRIOR TO THE EXPERIMENT. THE PROGRAM WAS A 156-FRAME UNIT IN BINARY NUMBERS. THE LOW-ERROR, RESPONSE-CONFIRMATION FORM OF THE PROGRAM PROVIDED THE MOST EFFICIENT CONDITIONS FOR LEARNING. NEITHER LEARNER MOTIVATION NOR ERROR-EVOKING FRAMES AFFECTED RESPONSE CONFIRMATION AND EXAMINATION FEEDBACK. THE RESULTS SUGGESTED THAT BOTH GOOD AND POOR STUDENTS PREFERRED TO LEARN UNDER WELL STRUCTURED CONDITIONS IN WHICH FEEDBACK IS MAXIMAL AND ERROR MISINTERPRETATION MINIMIZED. (JC)

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The Reinforcing Effects of Two Types of Confirmation in Programmed Instruction

Cooperative Research Project No. 2035

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1964

The research reported herein was supported by the Cooperative Research Program of the Office of Education, U.S. Department of Health, Education, and Welfare.

ED 003323

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The Reinforcing Effects of Two Types of Confirmation in Programmed Instruction[1]

The Problem and Related Research

One of the key concepts in the study of learning is the concept of reinforcement, and most learning theories deal with the relationship among reinforcement variables. Yet the concept of reinforcement is a troublesome one both in the laboratory setting and in the classroom. In the animal laboratory the techniques of reinforcement evoke little controversy; the E gives food to the hungry animal when the animal makes an appropriate response; or he gives water to a thirsty animal; or he turns off a painful shock and so on. Controversy arises when different theorists attempt to explain how reinforcers work, how the reinforcement "mechanism" operates to affect learning.

In the classroom setting the concept of reinforcement has less systematic status than it does in laboratory studies of learning. This is not to say that notions of reward and punishment have not been systematically discussed by educators; they certainly have, and are as old as the earliest writings on the subject of education. However, it is only recently that the concept of reinforcement has been introduced into the field of teaching as a systematic principle and not simply as a maxim about the benefits of reward.

The introduction of the principle of reinforcement into educational practice has been brought about by the programmed-instruction movement. In fact, this principle is one of the four or five commandments of programmed instruction. Every book or article dealing with programmed instruction tells

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1. The principal investigator wishes to thank Miss Janet Sigal and Mrs. Harry Jagoda for their assistance in the pilot studies and in preparing the statistical analyses.

the reader that immediate reinforcement of the correct response is one of the crucial characteristics of programs. In most of these writings the authors explicitly accept the position that the concept of reinforcement provides a useful and workable model for development of a systematic technology of instruction. Furthermore, in going from the laboratory to the classroom many writers have taken a seemingly simple and direct route by equating reinforcement and response confirmation. One can read in most any book or article on programmed instruction that confirmation of the correct response serves as a reinforcer, and for some writers, response confirmation serves as <u>the</u> reinforcement.

The idea that confirmation of the correct response is reinforcing, virtually represents a cornerstone of programming methodology as Lumsdaine (1962) has pointed out. But it is becoming increasingly apparent that the response-confirmation view of reinforcement is a very shaky cornerstone for there appears to be some disagreement and dissatisfaction about the role of reinforcement and the techniques of reinforcement in programmed instruction. Some writers, Lumsdaine (1962) for example, question the adequacy and the value of reinforcement concepts in programming methodology. Lumsdaine argues that when programmers are writing frames they are actually more concerned with the manipulation of prompting cues rather than the manipulation of reward schedules. Other writers while accepting the value of a reinforcement model are bothered by a certain vagueness in the model when it is applied to complex human learning situations. One of the major difficulties seems to be that of equating response confirmation with reinforcement.

There are two issues here, one issue concerns the utility of the concept of reinforcement in programmed instruction and the other issue concerns

shortcomings of the reinforcement model in all types of learning situations. The latter issue proceeds from an acceptance of reinforcement theory, and a dissatisfaction with the transition of reinforcement theory from the laboratory to the kinds of learning situations in which programmers are interested. However, the real issue for those interested in developing an instructional technology may simply be the question what reinforcement variables can we identify and how can we control them. The singular emphasis on response confirmation may be obstructing the search for maniputable reinforcement variables by treating response confirmation as if it were the only reinforcement available in situations of the programmed learning type.

It is true that terms such as knowledge of results, feedback, reward, and reinforcement are often cross-indexed in textbooks and used interchangeably (Bilodeau and Bilodeau 1961). But such generalization or overgeneralization can obscure important differences and may mislead us in our search for the controlling variables in the practical management of learning. One immediate effect of the premature acceptance of response confirmation as a critical feature of programs has been what Schramm (1962) refers to as the "hardening of program styles." While there has been some experimentation with programming methods, the great majority of programs have been constructed following the lead of the prototype, response-confirmation programs, and there has been little deviation from this style.

The recent research dealing with the problem of reinforcement in programmed instruction does not explicitly include the learner as a variable, but this research does raise questions about the reinforcing effect of response confirmation. There seems to be an increasing number of studies the results of which indicate that response confirmation is not a necessary condition in programmed learning. Krumboltz and Weissman (1962) found that

a no-confirmation group learned as well as a group receiving continuous confirmation; Moore and Smith (1962) showed that student achievement in a programmed learning task was not significantly affected by knowledge of results, that is knowledge of results in terms of response confirmation; and Ripple (1962) found no support for the view that response confirmation improves learning.

Arguments have been presented for making a distinction between confirmation and reinforcement. Gagné (1958) and Carr (1959) have taken the position that confirmation serves as a reinforcer when the task to be learned is intrinsically motivating. Ugelow (1962), on the other hand, contends that knowledge of results should have a reinforcing effect unless the learner has "no apparent desire to learn." All three writers suggest the inclusion of the learner as a variable and in so doing suggest that the reinforcing effects of response confirmation interact with the reinforcement history of the learner.

If response confirmation is a conditioned reinforcer, then we should not be surprised if its effectiveness in any given situation is determined by the learner's history and the particular learning situation.

An important question would seem to be, what kinds of variables determine the effectiveness of response confirmation. For example, how do motivational variables influence response confirmation? Is response confirmation effective only with well motivated Ss or can Ss with a high degree of task motivation dispense with response confirmation? And what about the role of negative confirmation, that is, the confirmation of errors? What effect do errors have on the reinforcing function of response confirmation.

According to Skinner (1958), error rate is a motivational variable. He

maintains that good programs minimize learner errorsin order to increase the frequency of positive reinforcements and thus maintain a high level of learner motivation. However, Pressey (1959) argues that learner errors can be useful in teaching because failures can be used to increase a learner's motivation. Smith (1959) also has suggested that failure on some items may contribute to the effectiveness of learning by enhancing the reinforcing effects of the successful response. There are two points of view here. The one espoused by Skinner is that aversive motivation should be avoided; and the view of Pressey and Smith is that certain aversive events, namely errors, can enhance the effect of positive events such as success.

Questions of the type raised above in which motivational variables are considered call attention to criterion variables other than achievement. Certainly achievement (including retention and transfer of learning) is a central criterion and it is naturally the most commonly used criterion variable. However, there are certainly other variables to be weighed; one of these is the learner's reactions to the learning task. Is the learner interested in continuing to learn the materials in question, or in spite of high achievement has he found the task so aversive as to avoid it when given the opportunity? For many education and training situations, the learner's interest in continuing to study is an important consideration. If a particular type of learning material, programmed or not, evokes avoidance behavior from the learner then the purpose of the material may be defeated.

There have not been many systematic studies investigating student attitude toward different programmed materials. However, in the Moore and Smith study cited above a questionnaire was used to determine student attitudes toward the programmed material. On the basis of the questionnaire data, the investigators concluded that the most effective kind of program

would be one that did not supply knowledge of results by response confirmation and one which included frequent examination items of the constructed-response type. The use of examinations points up an additional aspect of the confirmation-reinforcement dimension. In using response confirmation each step is extrinsically confirmed, while clusters or groups of steps are extrinsically confirmed using the examination-feedback technique. However, in learning sequences which contain only examination feedback, there is probably intrinsic confirmation provided in the sequential development of the material. Students do learn to confirm their own responses, particularly in carefully sequenced material. For example, in a programmed unit the frame sequence is a source of feedback; confirmation may be provided by the progress the learner makes from step to step. The learner's response to frame 1 is confirmed in his reading of frame 2 and so on.

The different effects of extrinsic response confirmation may be a reflection of the learners' prior experience and habits. There has been some suggestion that the step by step feedback provided by extrinsic response confirmation may be necessary for learners whose learning history has included relatively few success experiences. Learners who have a history of frequent rewards for learning, in other words, frequent success experiences, may not require step by step extrinsic confirmation. If the learner's reinforcement history affects his motivation[2] to learn certain materials, as it probably does, then we might expect highly motivated learners to require less extrinsic feedback than would learners with less motivation. Thus, we would expect response-confirmation feedback to be appropriate for the low-motivation learners and examination feedback to be

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2. Motivation as used here refers specifically to a particular subject matter, as in the case of binary numbers. A highly-motivated learner would be one with a high degree of interest in binary arithmetic.

appropriate with high-motivation learners.

The purpose of the present study was to compare the reinforcing effects of two kinds of confirmation, response confirmation and examination feedback under high, medium, and low student motivation or interest and under a high and low error-rate condition. We were interested in determining whether response-confirmation was as effective with highly motivated learners as with learners of relative low motivation and whether examination feedback was effective with learners of different motivation. We also wanted to determine whether student errors would increase the effectiveness of both response-confirmation and examination feedback.

Method

Experimental Design:

The three conditions of the study, type of confirmation, task motivation, and error rate were arranged in a 3 X 2 X 2 factorial design with high, medium, and low task motivation as one dimension, high and low error rate as a second dimension, and type of confirmation as a third dimension.

Subjects:

A total of 240 Ss participated in the study proper. However, 450 Ss participated in the first phase of the study in which a questionnaire was administered to determine interest in learning the materials to be used in the study. The sample of 450 Ss consisted of male and female students enrolled in Introductory Psychology courses at University College of Arts & Science, New York University. The 240 Ss were selected on the basis of their response to a two-part questionnaire (Appendix A).[3] One part of the questionnaire consisted

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3. 280 Ss were selected but 40 Ss failed to meet their appointments or were disqualified because they had prior knowledge of binary numbers, the learning materials used in the study. Only one student failed to complete the program itself.

of five forced-choice items and the second part consisted of nine items to be ranked in order of preference. The forced-choice items included five pairs in three of which the student had to choose between a preference for the study of number theory and something else such as the study of Latin verbs, or Hamlet, or Salesmanship. Thus, a student with a strong interest in number theory might score 3 if he chose that item in each of the three pairs. The ranking items consisted of nine subjects including the subject of binary numbers; the student was asked to rank the subjects in order of his preference. If binary numbers was ranked 1, 2, or 3 the student was given the score of 2; for a ranking of 4, 5, or 6 he was given the score of 1; and for a ranking of 7, 8, or 9 he was given the score of 0. Thus a total score of 5 on the questionnaire was possible.

The Ss were classified as high, medium, or low-motivated Ss in terms of their questionnaire scores. A student with a score of 4 or 5 was classified as having a high interest (high motivation) in the study of binary numbers; a score of 2 or 3 classified the student as one having medium interest (medium motivation); a score of 0 or 1 classified the student as one having low interest (low motivation).

The Ss in the three motivation groups were randomly assigned to the two confirmation and the two error conditions.

Materials:

The programmed material consisted of four forms of a 156 frame unit in binary numbers. These programs are an extended and revised version of a program used in a group of experiments by Silverman and Alter (1961). The revision of the binary number programs used in the present study was based on a series of pilot studies. The purpose of the pilot studies was to develop the four forms of the program, a low-error and a high-error form, as well as

a response-confirmation and examination-feedback form. The low error-response confirmation version served as the basic program form. It was this program that was modified to create a high-error form and an examination-feedback form.

The examination-feedback program was basically the response confirmation program excluding confirmation for each response and including four groups of five-item self-scoring quizzes (see Appendix B for a sample of quiz number 1). These examinations or quizzes were set off distinctively and were prefaced by instructions to the student informing him that the purpose of the quizzes was to help him determine how well he was doing. The examination frames did provide response confirmation.

The response-confirmation program also contained the same examination frames, but they were not set off distinctively and they were not labeled in any way. They simply were a part of the program sequence.

The high and low error forms were developed by modifying the prompts and/or frame sequence in 30 frames scattered through the 156 frames of the program.[4] In some cases prompts were withdrawn to create a high-probability error frame and in other cases prompts were inserted to create a low-probability error frame. The series of pilot studies was used to test and revise the programs in order to construct a low-error form in which the error-rate would be eight percent or less and a high error form which would contain approximately 30 error-evoking frames, while all other frames would be the same as those contained in the low-error form. (See Appendix C for a sample comparison of low and high error frames.)

The programs were presented in three-ring binders[5] containing a plastic slider to cover succeeding frames and the response-confirmation column.

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4. Frames numbered 11, 12, 21, 22, 23, 24, 25, 32, 43, 49, 54, 71, 80, 85, 86, 87, 98, 105, 106, 112, 116, 118, 129, 130, 133, 138, 141, 142, 145, 151.

5. The Learn Ease 79.022 Binder manufactured by the National Blank Book Company, Holyoke, Massachusetts.

Procedure:

The programs and tests were administered to small groups of Ss. Depending on scheduling and appointment variables, the group ranged in size from two to 25. Low and medium-motivation Ss were mixed in the groups, but high-motivation Ss were run in separate groups.

All Ss in the low and medium motivated-groups received similar instructions at the outset of the experiment. They were simply told that they were participating in a study of learning and were then given a five-item preliminary test to complete. The purpose of this test was to determine whether the Ss could perform simple manipulations with binary numbers. Subjects who were able to do four or five of the items were dropped from the experiment.[6] Following the pretest, the Ss were shown how to use the Learn-Ease binders and were told to proceed. As each S finished the program, he was given a 20 item achievement test. When that test was completed, the S was given a four-item questionnaire (Appendix D) to fill out and was then given an appointment to return the following week. The following week the Ss were given a speed test of eight items (Appendix D). The items were dictated by E at the rate of one item every 10 seconds. After the speed test, a retention test was administered. The retention test contained 22 items and except for the first two items and a revised order of items it was the same as the first test.

The Ss in the high-motivation group were given different instructions. Otherwise they were treated the same as the Ss in the low and medium-motivation groups. The high-motivation Ss were told at the beginning of the experiment that the topic chosen for them to learn was one in which

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6. Typically an S scored either a four or five or a zero. Only 12 Ss received a score of 3 and 50 Ss scores of 1 or 2. These Ss appeared in equal number in each of the groups.

they had indicated an interest when they filled out the questionnaire. They were further told that the study of binary numbers has importance in relationship to computer technology and that educated people should know something of computers, in the present day and age. Finally, the number game "NIM" was briefly described and the Ss were told that they would learn how to win this game as they acquired a knowledge of binary numbers. The purpose of these special instructions was to maintain a high level of interest in the programmed material. Following the instructions these Ss proceeded as did the Ss in the low and medium-motivation groups.

Results

Table 1 shows the mean number of errors made by the high and low-error groups and by the response-confirmation and examination-feedback groups. The table is in two parts. Part A shows the mean number of errors made in the 30 frames which were error-evoking for the high-error groups and were not error-evoking for the low-error groups. Part B shows the mean number of errors for the 126 frames which were identical for both the high and low-error groups. The analysis of variance for the error data shown in Table 2 indicates that the differences between high and low error and between response confirmation and examination feedback were significant ($P<.01$) for both the 20 modified frames and the 126 non-modified frames. The high-error group made more errors than the low-error group and the examination-feedback group made more errors than the response-confirmation group.

Table 1

Means and SDs of Errors Made in Working Through Programs

	A. 30 Modified Frames				B. 126 Unmodified Frames			
	High Error		Low Error		High Error		Low Error	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Response Confirmation	6.70	4.04	2.98	2.31	13.85	10.03	9.23	5.08
Examination Feedback	9.00	5.37	4.43	2.92	21.50	15.38	12.90	7.77

Table 2

Analysis of Variance of Error Data

	30 Modified Frames			126 Unmodified Frames		
Source	SS	df	F	SS	df	F
Error	1029.20	1	68.57 (P<.01)	2626.20	1	24.34 (P<.01)
Confirmation	210.94	1	14.05 (P<.01)	1921.00	1	17.85 (P<.01)
E X C	10.84	1	-	238.00	1	2.21
Within Groups	342.32	236		25404.78	236	
Total	4793.30	239		30184.00	239	

Scholastic Aptitude Test[7] scores were available for all the Ss and because of the likelihood that interest in studying binary numbers might be correlated with mathematical aptitude an analysis of variance of the mathematical aptitude scores was done. The means and SDs of the mathematical

7. Published by the College Entrance Examination Board, Box 592, Princeton, New Jersey.

aptitude scores are shown in Table 3 and the analysis of variance is shown in Table 4. The analysis clearly indicates that interest and aptitudes were positively correlated.

Table 3

Means and SDs of Mathematical Aptitude Test Scores

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	605.75	601.75	594.75	606.00	544.85	553.65
	SD	61.60	48.89	59.31	72.04	51.90	86.33
Examination Feedback	Mean	606.40	587.50	587.55	569.15	558.85	542.30
	SD	54.07	68.38	66.37	46.19	65.35	85.05

Table 4

Analysis of Variance of Mathematical Aptitude Scores

Source	SS	df	MS	F
Error	2381.40	1	2381.40	-
Confirmation	5041.66	1	5041.66	1.13
Motivation	112,559.15	2	56,279.58	12.66
C X E	8143.28	1	8142.28	1.83
C X M	5620.24	2	2810.12	-
E X M	796.60	2	398.30	-
E X C X M	575.52	2	287.76	-
Within Groups	1,013,546.40	228	4445.38	

Because aptitude or initial ability is an important source of variation in this study analyses of covariance is used in adjusting the data for the experimental variables tested below.

The correlation between total number of errors made on the program and mathematical aptitude scores was -.26. An analysis of covariance adjusting the error scores in terms of the aptitude scores showed as did the analysis of variance in Table 2 that there were significant differences between the high and low-error groups and between the response-confirmation and examination-feedback groups. This analysis also revealed an additional bit of information in that it showed a significant interaction between the motivation and confirmation variables. The Ss receiving immediate response confirmation generally made fewer errors on the program. However, the differences between response confirmation and examination feedback are smallest for the high-motivation Ss and largest for the low-motivation Ss with the medium-motivated Ss falling in between. The means and SDs for the total error scores are presented in Table 5 and the analysis of covariance is presented in Table 6.

Table 5

Means and SDs of Total Error Scores

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	19.90	13.70	21.95	11.15	20.85	11.90
	SD	15.62	7.43	14.47	6.74	10.98	6.43
Examination Feedback	Mean	27.20	16.25	29.55	17.05	38.40	25.50
	SD	20.98	9.33	16.65	8.65	22.14	21.57

Table 6

Analysis of Covariance of Total Error Scores

Source	Adj. SS	df	F
Error	6939.22	1	33.34 (P<.01)
Confirmation	4339.25	1	20.85 (P<.01)
Motivation	162.02	2	-
C X E	355.11	1	1.71
C X M	1528.98	2	3.67 (P<.05)
E X M	71.97	2	-
E X C X M	39.91	2	-
Within Groups	47,252.19	227	

The Ss' achievement was measured by three tests: an achievement test given immediately upon completion of the program, a speed test given one week later, and an alternate form of the original achievement test given after the speed test. It should be noted that the alternate form of the achievement test contained 22 items, two more than the original test. The speed test and second achievement tests are referred to as retention tests in the text and the tables below.

Table 7 presents the means and SDs of the achievement and retention test scores and Table 8 presents the analyses of covariance for these test data adjusted in terms of the mathematical aptitude scores.

Table 7

Means and SDs of Achievement and Retention Test Scores

Immediate Achievement Test (20 items)

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	13.80	14.65	12.40	15.70	11.25	12.15
	SD	3.89	3.69	4.38	2.33	4.39	3.65
Examination Feedback	Mean	15.15	12.95	11.90	11.25	10.35	12.00
	SD	4.09	3.97	5.51	4.18	5.11	4.69

Retention Test (Speed Test - 8 items)

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	5.40	6.10	5.75	6.00	5.65	5.35
	SD	1.74	1.58	1.51	1.61	1.20	1.65
Examination Feedback	Mean	6.20	5.75	5.10	5.95	4.85	5.30
	SD	1.12	1.58	2.51	1.25	1.42	1.90

Retention Test (22 items)

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	15.75	17.15	14.75	17.40	12.65	14.55
	SD	4.58	3.17	4.06	1.98	5.15	3.84
Examination Feedback	Mean	17.85	15.60	14.30	13.65	12.95	13.10
	SD	3.83	3.97	5.71	4.09	4.95	5.60

The analyses in Table 8 reveal that of the three tests only the 22 item retention test provided significant differences among the experimental variables. The results of this retention test shown in Table 7 and analyzed in Table 8 indicate that in general the high-motivation Ss achieved higher scores than did the medium-motivation Ss and the low-motivation Ss achieved the lowest scores. The high, medium, low order also occurred for the immediate achievement test and for the speed test, but these differences were not significant when subjected to a covariance analysis.

Table 8 also shows a significant interaction between the confirmation and the error variables. This interaction comes from the difference in the low-error condition between response confirmation and examination feedback (including all three motivation conditions). The response-confirmation group mean (16.36) is significantly higher than the examination-feedback's group mean (14.12), while the two high-error means (14.38 and 15.03) do not differ significantly from each other.

Table 8

Analyses of Covariance of Achievement and Retention Test Scores

	Immediate Achievement			Retention (Speed Test)			Retention Test		
Source	Adj. SS	df	F	Adj. SS	df	F	Adj. SS	df	F
Error	39.09	1	2.48	5.47	1	2.19	30.02	1	1.80
Confirmation	39.77	1	2.52	.73	1	-	14.77	1	-
Motivation	75.83	2	2.41	.90	2	-	134.99	2	4.05(P<.05)
C X E	32.05	1	2.03	1.00	1	-	78.56	1	4.71(P<.05)
C X M	37.84	2	1.20	5.25	2	1.05	41.18	2	1.23
E X M	41.79	2	1.33	2.44	2	-	19.94	2	-
E X C X M	63.18	2	2.00	12.44	2	2.49	9.37	2	-
Within Groups	3579.03	227		566.34	227		3784.58	227	

Table 9 presents a summary of the product-moment correlations between the mathematical aptitude test scores and the achievement and retention test scores for the error and confirmation conditions. The motivation conditions are collapsed into the error and confirmation conditions. This table shows that the correlation between mathematical aptitude and achievement and retention is significant. Only the response-confirmation, low-error group under the speed test conditions failed to show a significant correlation. The examination-feedback correlations are consistently higher than the response-confirmation correlations. However, the only significant difference (at the .05 level or better) was between examination feedback and response confirmation under the low-error condition.

Table 9

Correlations Between Aptitude Test Scores and Achievement and Retention Test Scores

	Immediate Achievement		Retention (Speed Test)		Retention Test	
	High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	.38*	.38**	.32*	.12	.43*	.42*
Examination Feedback	.57*	.46*	.51*	.45*	.50*	.54*

** significant at the .01 level
* significant at the .05 level

The time (in minutes) it took each S to complete the program was noted during the experiment. The means and SDs of these time scores are shown in Table 10 and the analysis of covariance of these scores is presented in Table 11. The table of means and the statistical analysis show that Ss working under the high-error condition took longer on the average to complete the program than did Ss working under the low-error conditions. Also the response-confirmation condition led to shorter program-completion times than did the examination-feedback condition. There was a significant interaction between the confirmation and error conditions. This interaction stemmed from the slow program-completion time of the examination-feedback, high-error group. In fact it was the scores of this group that accounted for the overall significant difference between high and low error and between examination feedback and response confirmation seen in the analysis of covariance.

Table 10

Means and SDs of Time Scores in Minutes

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	58.40	59.10	55.90	57.35	57.25	56.85
	SD	12.90	13.57	10.77	11.51	13.36	10.87
Examination Feedback	Mean	67.90	62.90	65.70	57.25	69.25	63.00
	SD	15.71	12.08	16.15	10.11	17.78	14.18

Table 11

Analysis of Covariance for Time Scores

Source	Adj. SS	df	F
Error	604.71	1	3.39(P<.05)
Confirmation	2590.15	1	14.51(P<.01)
Motivation	449.77	2	1.26
C X E	854.77	1	4.78(P<.05)
C X M	241.08	2	-
E X M	14.51	2	-
E X C X M	125.24	2	-
Within Groups	40,526.20	227	

The differences observed in the time scores suggest the use of an efficiency index as a measure of the effectiveness of the experimental variables. An efficiency score was calculated for each S by dividing his achievement test score by his score on the program and multiplying the quotient by 100. Thus, if a given S answered 14 questions correctly on the achievement test after having taken 68 minutes to complete the program, his efficiency score would by 14/68 X 100 or 20.59; an S who answered 11 questions correctly taking 55 seconds to complete the program would have an efficiency score of 11/55 X 100 or 20.00

The means and SDs of the efficiency scores are presented in Table 12 and the analysis of covariance for these data is presented in Table 13. These tables show that Ss in the low-error conditions achieved higher efficiency scores than Ss in the high-error conditions and that Ss who received immediate

response confirmation achieved higher efficiency scores than did Ss receiving only examination feedback.

Table 12

Means and SDs of Efficiency Scores

		High Motivation		Medium Motivation		Low Motivation	
		High Error	Low Error	High Error	Low Error	High Error	Low Error
Response Confirmation	Mean	24.58	25.94	22.93	28.32	20.55	22.99
	SD	8.61	7.82	9.07	6.53	10.37	7.11
Examination Feedback	Mean	23.18	21.27	19.08	20.64	17.68	20.02
	SD	8.69	7.85	9.80	9.10	12.58	9.53

Table 13

Analysis of Covariance of Efficiency Scores

Source	Adj. SS	df	F
Error	295.27	1	4.17(P<.05)
Confirmation	683.57	1	9.65(P<.01)
Motivation	12.46	2	-
C X E	17.26	1	-
C X M	39.51	2	-
E X M	113.41	2	-
E X C X M	44.33	2	-
Within Groups	16,077.06	227	

Table 14 shows the product-moment correlations between the mathematical aptitude test scores and the efficiency scores for the four experimental conditions; the motivation conditions are collapsed into the error and confirmation conditions. Here as in Table 9 the examination-feedback correlations are higher than the response-confirmation correlations. The difference between the highest correlations of .58 for the examination-feedback, high-error condition and the lowest correlation of .27 for the response-confirmation, low-error group is significant at better than the .05 level of confidence. Considering these two groups, we can say that the correlation between learning with a program and initial aptitude is greater when feedback is minimized and errors are increased. It should also be pointed out that the group with the lowest correlation, the response-confirmation, low-error group consistently achieved the highest efficiency scores as shown in Table 12.

Table 14

Correlations Between Aptitude Test Scores and Efficiency Scores

Response	High Error	Low Error
Response Confirmation	.46**	.27*
Examination Feedback	.58**	.43**

** significant at the .01 level
* significant at the .05 level

The questionnaire completed by the Ss at the end of the first session contained four items. The first item asked the S to estimate the number of

errors he had made in the program by choosing among eight classes of estimates (see Appendix D). To evaluate the responses to this item, the Ss were classified into two categories. One category consisted of Ss who estimated that they had made more than 20 errors (the mean error production for all Ss was 20.15) and the other category consisted of Ss who estimated less than 20 errors.

Table 15 shows the frequency-of-error estimates classified according to the four confirmation-error conditions in part A and classified according to the three motivation conditions in part B. The number in the parentheses in each cell indicates the actual number of Ss making less than or more than 20 errors. This table shows that the response-confirmation, low-error group contained more Ss who estimated less than 20 errors than did the other three groups. A Chi-square of 16.87 with 3 df was significant at the .01 level of confidence. The response-confirmation, low-error group was also significantly lower than the other groups in terms of actual errors made. The examination-feedback, high-error group was significantly higher in actual errors made, but as can be seen in Table 15, these Ss did not give higher error estimates than the examination-feedback, low-error group or the response-confirmation, high-error group.

Table 15 also shows that the high-motivation group estimated making fewer errors than did the medium and low-motivation groups. The Chi-square was 10.47 significant at the .01 level of confidence for 2 df. However, in terms of the actual number of errors made, there was no significant difference among the three motivation conditions using the classification shown in Table 15.

Table 15

Error Estimates in Terms of the Number of Ss Estimating More or Less Than 20 Errors

Part A

Estimate	Res.-confirm. Low Error	Exam-feedback Low Error	Res.-confirm. High Error	Exam-feedback High Error
Less than 20	59 (53)	44 (36)	45 (37)	44 (22)
More than 20	1 (7)	16 (24)	15 (23)	16 (38)

Part B

Estimate	High Motivation	Medium Motivation	Low Motivation
Less than 20	71 (53)	66 (51)	55 (44)
More than 20	9 (27)	14 (29)	25 (36)

Note - The Chi-square for the error estimates in part A = 16.87 ($P<.01$); the Chi-square for the actual errors (numbers in parentheses) in part A = 33.93 ($P<.01$)

For part B the Chi-squares = 10.47 ($P<.01$) for the estimates and 2.50 for the actual errors.

The second item of the questionnaire asked the S to rate the difficulty of the program along a five-point scale from Very Easy, to Easy, to Slightly Difficult, to Difficult, to Very Difficult. For the purpose of analyzing the responses to this item the Ss were classified into two categories. One category consisted of Ss who rated the program as Very Easy or Easy and the second category consisted of Ss who rated the program as Slightly Difficult,

Difficult, or Very Difficult. Table 16 shows the frequency of Ss in these two categories classified according to the four error-confirmation conditions in part A and classified according to the motivation conditions in part B. The table shows that more Ss in the response-confirmation, low-error group rated the program as Very Easy or Easy than did the Ss in each of the other three groups. The Chi-square for part A was 25.12 (df 3, P<.01).

Part B of Table 16 shows that more Ss in the low-motivation group rated the program in the Slightly Difficult-Difficult-Very Difficult category than did the Ss in the high or medium-motivation groups. The Chi-square for part B was 12.14 (df 2, P<.01).

Table 16

Frequency of Ss Rating Program
Very Easy-Easy or Slightly Difficult-Very Difficult

Part A

Estimate	Res.-confirm. Low Error	Exam-feedback Low Error	Res.-confirm. High Error	Exam-feedback High Error
Very Easy-Easy	39	18	16	18
Slightly Difficult-	21	42	44	42

Part B

	High Motivation	Medium Motivation	Low Motivation
Very Easy-Easy	37	36	18
Slightly Difficult-	43	44	62

Note - Chi-square for Part A = 25.12, df 3, P<.01; Chi-square for Part B = 12.14, df 2, P<.01.

The third item of the questionnaire asked the Ss to answer "Yes" or "No" to the question, "Did you find the program interesting?" Table 17 shows the frequency of "Yes" and "No" responses. Part A of Table 17 indicates that there were no significant differences in the frequency of "Yes" responses among the four confirmation-error conditions. For all four conditions the percent of "Yes" responses was about 75. Part B of Table 17 shows that the high-motivation group gave more "Yes" responses than the medium or low-motivation groups. The highs answered "Yes" 90 percent of the time. This difference between the high motivation and the other two motivation groups was significant at the .01 level (Chi-square = 14.07, df 2).

Table 17

Frequency of "Yes" and "No" Responses to Item 3 of Questionnaire

Part A

Answer	Res.-confirm. Low Error	Exam-feedback Low Error	Res.-confirm. High Error	Exam-feedback High Error
Yes	45	44	48	44
No	15	16	12	16

Part B

Answer	High Motivation	Medium Motivation	Low Motivation
Yes	72	56	53
No	8	24	27

Note - Chi-square for part A = .96; Chi-square for part B = 14.07, df 2, P<.01.

The fourth questionnaire item asked, "Would you like to study other subjects this way?" The frequency of "Yes" and "No" responses is shown in Table 18 where it can be seen that there were no significant differences among the groups. In Part A, all four groups gave around 70 percent "Yes" responses. In part B, the high-motivation group gave an 80 percent Yes response. This was the highest percentage of the three motivation groups, but the difference between the high group and the other two groups was not significant. The Chi-square was 4.52 and for 2 df a Chi-square of 5.99 is required at the .05 level of confidence.

Table 18

Frequency of "Yes" and "No" Responses
to Item 4 of Questionnaire

Part A

Answer	Res.-confirm. Low Error	Exam-feedback Low Error	Res.-confirm. High Error	Exam-feedback High Error
Yes	45	44	41	41
No	15	16	19	19

Part B

Answer	High Motivation	Medium Motivation	Low Motivation
Yes	64	54	53
No	16	26	27

Note - Chi-square for Part A = 1.04; for part B = 4.52.

The results of the questionnaire data show that the conventional program, that is, the response-confirmation, low-error program led to a lower error estimate than was made in any of the three other program forms. More Ss taking the response-confirmation, low-error program rated the program as Very Easy or Easy than did the Ss taking the other three programs. The high-motivation Ss gave lower error estimates than the other two motivation conditions and the high-motivation Ss also gave more frequent "Yes" answers to the question whether they found the program interesting. The low-motivation Ss gave more ratings in the Slightly Difficult-Difficult-Very Difficult category than did the other two motivation conditions.

Discussion

The analysis of the errors made on the program shows that the high and low-error groups did differ from each other with respect to the 126 unmodified frames as well as the 30 modified or error-evoking frames. In spite of the fact that the 30 modified frames were designed to be high-probability error items, the mean number of errors made on these frames was only 6.70 for the response-confirmation group and 9.00 for the examination group. However, the error-evoking properties of these 30 frames did affect the other frames such that the high-error group also made more errors on the unmodified frames. It should be noted that although the groups differed from each other, the size of the differences was not large; the average error percent for the high-error groups was 17 percent and for the low-error group 10 percent.

The fact that the examination-feedback groups made more errors on the average than the response-confirmation groups is of interest, for it indicates the relevance of feedback in enabling or encouraging the learner to reduce

the number of errors he makes in working through a programmed unit. In this regard the questionnaire data are relevant since these data point out that although the examination-feedback, high-error group made more errors than the response-confirmation, high-error group, the Ss in the examination-feedback group evidently did not recognize that they had been making a relatively large number of errors.

In examining the effects of the experimental variables in this study, it is perhaps appropriate to consider first the question of the overall effectiveness of the program itself. In other words, was the program a valid teaching tool? The data presented in Table 7 of the Results section show (although the results are not given in percentages) that the average achievement levels for the immediate achievement test were 71 percent for the high-motivation group, 64 percent for the medium-motivation group and 57 percent for the low-motivation group. These percents are somewhat low because the achievement test was not designed to be a measure of the direct terminal objectives of the program, but was rather designed to discriminate among possible differences in achievement among Ss in the various experimental conditions. However, the first 14 items of the test were directly related to the objectives of the program, that is, to teach addition and subtraction of binary numbers. When the achievement test data are recalculated using only the 14 addition and subtraction items, the results show that the high-motivation group averages 77 percent, the medium-motivation group averages 69 percent, and the low-motivation group averages 66 percent. While these figures are still not exceptionally high, they are acceptable and indicate that the program did teach. Itshould be mentioned that an analysis of the effects of the experimental variables in terms of the 14 direct-achievement items or the six other (actually transfer-of-training) items did not reveal

results different from those presented in Table 8.

The only significant differences found in the achievement and retention test scores occurred in the scores for the 22 item retention test where the high-motivation group achieved the best scores and the low-motivation group the poorest scores. Although the confirmation and error conditions did not result in overall significant differences, there was an indication in the data that under the low-error condition, the response-confirmation group achieved higher scores than the examination-feedback group.

The retention test data reported here and the recent findings of Krumboltz & Weisman (1962) suggest that delayed tests may provide more sensitive measures of certain programmed learning effects than are provided by immediate criterion tests. Both studies show significant differences with retention tests but no significant differences with immediate criterion tests. However, in the present study an efficiency index which included the immediate achievement test scores and time scores did produce significant differences.

When the data are analyzed in terms of time scores and efficiency scores, the motivation differences drop out and the error and confirmation conditions show significant effects. It is interesting to note that subject interest or motivation was not correlated with the time scores while the error variable and confirmation variables were correlated. These results appear to indicate that programs with a relatively high number of difficult or error-evoking frames slow down the learner, and the reduction of feedback of the response-confirmation type also slows down the learner's progress.

The most efficient learning seems to take place under low-error, response-confirmation conditions. The total low-error, response-confirmation group mean is significantly different from the low-error, examination-feedback group mean ($F = 11.39$, $P<.01$) and from the high-error, examination-feedback

group mean ($F = 11.81$, $P<.01$) while it just misses being significantly different from the high-error, response-confirmation group mean ($F = 3.77$, with 1 and 118 df an F of 3.92 is required at the .05 level for a two-tailed test).

The apparent superiority of the low-error, response-confirmation group's performance is highlighted by the correlations between the mathematical aptitude scores and the achievement, retention and efficiency scores. The low-error, response-confirmation correlations are consistently the lowest. Although there were only two places where the low-error, response-confirmation correlation differed significantly from those of the other groups, the consistency does suggest that when feedback is immediate and errors are reduced the correlation between initial aptitude and learning is lowered. Skinner (1958) has indicated that programmed instruction should have the effect of lessening the correlation between ability and mastery of a given subject matter while allowing a correlation between speed of learning and initial aptitude. There is some support for that contention here and in an earlier study by Porter (1959). Porter found a positive relationship between intelligence scores and achievement during conventional instruction in spelling while no significant relationship between intelligence and achievement was revealed when the spelling instruction was programmed. However, Shay (1961) found a relationship between learning by means of programmed instruction and intelligence (the subject matter was a fourth grade unit in roman numerals), but he failed to find a relationship between intelligence and the size-of-step variable. Size of step was defined in terms of error rate such that large-step programs evoked more errors than medium-step programs, and medium-step programs evoked more errors than small-step programs. Thus, the Shay study showed as did the present study that

programmed instruction was correlated with ability, but the Shay study did not show the error variable to be related to ability as is suggested in this study.

The present study and the two studies cited above differ in respect to subject matter, programming form, and students, but all three studies do lead to the suggestion that the variables involved in the relationship between initial ability and achievement by means of programmed instruction requires clarification.

The data from this study and from a study by Melching (1964), who showed that low-ability Ss requested about three times as much feedback and made three times as many program errors as high-ability Ss, suggest that the crucial variable may be feedback or a combination of feedback and error rate. It would appear that a program designed to maximize feedback and reduce errors would be of direct benefit to the low-ability learner.

There was no evidence in this study to support the view that highly-motivated Ss require less extrinsic feedback of the response-confirmation type. Considering the efficiency scores, response confirmation was more effective than examination feedback for all three motivation groups. Furthermore, there was no support for the idea that errors might increase the reinforcing effects of both response confirmation and examination feedback. The low-error condition resulted generally in higher efficiency scores, and the combination of low error and response confirmation resulted in the highest efficiency scores.

The questionnaire data further support the superiority of the low-error, response-confirmation group in that more Ss in this group saw the program as "Very Easy" or "Easy" while this group equalled the other groups in the number of Ss who found the program interesting.

There was no indication that the high-motivation Ss were less interested in the program than the medium or low-motivation Ss. On the contrary, the high-motivation group gave more "Yes" responses to the question "Did you find the program interesting?" than either of the other two motivation groups. Considering that the motivation variable used here is highly correlated with initial aptitude (Table 4) we can also conclude that Ss of high ability found the program format interesting and were not bored by the step by step procedure. Of the eight Ss who answered "No" to this question one was in the low-error, response-confirmation group; three were in the high-error, response-confirmation group; one was in the low-error, examination-feedback group; and three were in the high-error, examination-feedback group.

This study presents results which are not consistent with the findings of Krumboltz and Weisman (1962), Moore and Smith (1962) and Ripple (1962) all of whom found that student achievement was not differentially affected by continuous response confirmation. However, the differential effects seen in this study emerged largely in the analysis of the time and efficiency scores. Such dependent variables were not used in the studies cited above.

The question of the reinforcement value (or function) of response confirmation has not been answered here. The results of this study only suggest that response confirmation is an important condition of programmed teaching, but it was not significantly influenced by motivational variables in the way we would expect a reinforcer to be influenced.

Conclusions and Implications

1. The low-error, response-confirmation form of the program provided the most efficient conditions for learning.

2. Learner motivation did not affect response confirmation and examination feedback differently.
3. Error-evoking frames did not affect response confirmation and examination feedback differently.
4. The results of this study suggest that both good and poor students prefer to learn under well structured conditions in which feedback is maximal and the learning materials are arranged (programmed) so as to minimize misinterpretation and errors. While it is popular to assert that good students like "to be challenged," the results shown here suggest that all students want to learn before they are challenged. A program which teaches effectively can prepare the learner to meet the challenge of subsequent examinations. Perhaps the optimum combination will be feedback-rich, error-free programs which lead to examination or criterion frames which in turn will provide the rewards for learning sought by the well prepared learner.

BIBLIOGRAPHY

Glaser, R. A., Klaus, D.J. & Reynolds, J. H. Study Skills in Learning. In Annual Review of Psychology. 10, 1961, Palo Alto, California.

Gray, W. D., Self-instructional devices: A review of current concepts. Tech. Rep. WP 59-505, Wright Air Development Center, 1959.

Hough, J. B. A review of factors in learning efficiency. AFOSR 2958-pub Air Research and Development Command. U.S. Air Force. Washington, D.C., 1959.

Krumboltz, J.D. & Weisman, R. G. The effect of intermittent confirmation in programmed instruction. J. educ. Psychol. 1962, 53, 250-253.

Lumsdaine, A. A. Some theoretical and practical problems in programmed instruction. In J. E. Coulson (Ed.) Programmed learning and Computer - based instruction. New York John Wiley & Sons, 1962.

Nelson, W. E. Programmed instruction under a subject-controlled feedback schedule. Paper read at National Society for Programmed Instruction meetings in San Antonio, Texas, April 1964.

Rosen, V. J. and Smith, W. J. The role of knowledge of results in programmed instruction. Tech. Rep. AF - AFOSR 61-31 Bucknell University 1963.

Porter, D. Some effects of year long teaching machine instruction. In E. Galanter (Ed.) Automatic Teaching: The State of the Art. New York John Wiley & Sons, 1959.

Pressey, S. L. Certain major psychological issues appearing in the conference on teaching machines. In E. Galanter (Ed.) Automatic Teaching: The State of the Art. New York John Wiley & Sons, 1959.

Ripple, R. E. A comparison of the effectiveness of a programmed text with three other methods of presentation. Cornell University, 1960.

Schramm, W. Programmed Instruction. The Fund for the Advancement of Education, 1962.

Bibliography

Bilodeau, E. A., Bilodeau, Ira McD. Motor Skills in Learning. in Annual Review of Psychology 12, 1961, Palo Alto, California.

Carr, W. J. Self-instructional devices: A review of current concepts. Tech. Rep. TR 59-503, Wright Air Development Center, 1959.

Gagné, R. M. A review of factors in learning efficiency. AFOSR TN58-924 Air Research and Development Command. U.S. Air Force. Washington, D.C., 1958.

Krumboltz, J.D. & Weisman, R. G. The effect of intermittent confirmation in programmed instruction. J. educ. Psychol. 1962, 53, 250-253.

Lumsdaine, A. A. Some theoretical and practical problems in programmed instruction. in J. E. Coulson (Ed.) Programmed Learning and Computer - Based Instruction. New York: John Wiley & Sons, 1962.

Melching, W. H. Programmed instruction under a subject-controlled feedback schedule. Paper read at National Society for Programmed Instruction meetings in San Antonio, Texas, April 1964.

Moore, W. J. and Smith, W. J. The role of knowledge of results in programmed instruction. Tech. Rep. AF - AFOSR 61-54 Bucknell University 1962.

Porter, D. Some effects of year long teaching machine instruction. in E. Galanter (Ed.) Automatic Teaching: The State of the Art. New York: John Wiley & Sons, 1959.

Pressey, S. S. Certain major psychoeducational issues appearing in the conference on teaching machines. in E. Galanter (Ed.) Automatic Teaching: The State of the Art. New York: John Wiley & Sons, 1959.

Ripple, R. E. A comparison of the effectiveness of a programmed text with three other methods of presentation. Cornell University, 1962.

Schramm, W. Programmed Instruction. The Fund for the Advancement of Education, 1962.

Shay, C. B. Relationship of intelligence to step size on a teaching machine program, J. educ. Psychol., 1961, 52, 98-103.

Skinner, B. F. Teaching Machines. Science, 1958, 128, 969-977.

Smith D. E. P. Speculations: Characteristics of successful programs and programmers. In E. Galanter (Ed.) Automatic Teaching: The State of the Art. New York: John Wiley & Sons, 1959.

Ugelow, A. Motivation and the automation of training: A literature review. Aerospace Medical Research Laboratories Tech. Rep. MRL-TDR 62-15 Wright Patterson AFB, Ohio, 1962.

APPENDICES

Appendix A

Preliminary Questionnaire

P. L. Experiment
R. E. Silverman

Name _____
Date _____

I

Which would you prefer to study? (encircle your choice)

1. a) Hamlet or b) Number theory

In each of the following five pairs encircle the subject you would prefer to study.

2) a) Latin Verbs or b) Number theory

3) a) Salesmanship or b) Latin Verbs

4) a) Number theory or b) Hamlet

5) a) Latin Verbs or b) Hamlet

6) a) Salesmanship or b) Number theory

II

Below is a list of subjects some of which will be used this year in an experimental study of learning. Since you will probably participate in this experiment, you are now asked to rank the subjects in the order of your preference. Place a 1 in the parentheses next to the subject you most prefer, a 2 next to the second preferred one and finally on down to 9 to indicate the least preferred one.

Modern Algebra	( )
Ancient Civilization	( )
Department Store Management	( )
Sociology of Urban Area	( )
Greek Drama	( )
Computer Arithmetic (Binary Numbers)	( )
Economic Theory	( )
Anatomy of the Eye	( )
Atomic Theory	( )

Appendix B

SELF-SCORING QUIZ #1

The next five items are quiz items. Write your answer to each one in the appropriate place and then check the answer by moving the slider down below the line. Please be sure to write your answers before you check them and do not change your answers once you have checked them. These self quizzes are to help you to determine how well you are doing and for the programmer to determine how well the program teaches. So please remember to write your answer before checking it.

33. We use the phase positional notation in our arithmetic systems because we can change the quantity a digit represents by _____*****_____.

note - ***** means answer with more than one word

---

changing its position

34. When a mileage indicator reads b a we have

b	a
	7

traveled _____ miles.

---

seven

35. Using the decimal system, column a of a mileage indicator cannot show more than _____ miles.

---

nine

36. What happens to columns a and b on the indicator when we go more than nine miles?

b	a
	9

Answer in words.

---

a becomes 0 and b becomes 1

37. In the decimal system of numbering, we use how many digits?

---

ten

Appendix C

Sample Comparison of High and Low Error Frames

32. (Low Error) If 8 is the highest number, we have only _____ different digits (remember 0 is a digit too).

---

nine

32. (High Error) If 8 is the highest number, we have only _____ different digits.

---

nine

71. (Low Error) If a binary system is a two digit system, a system having only four digits would be called a quatern_____ system.

---

quaternary

71. (High Error) A system having only four digits would be called a _____ system.

---

quaternary

116. (Low Error) Binary Addition

```
  c b a
  1 0 1
+ 1 1 1
-------
1 1 0 0
```

By carrying 1 into col. b and then 1 into col. c.

Now do this example ——————

```
  c b a
  1 1 0
+ 1 1 1
-------
```

---

1 1 0 1

116. (High Error) Binary Addition

```
  101          110
+ 111        + 111
-----        -----
a)           b)
```

---

a) 1100
b) 1101

Appendix D

Preliminary Test

Name _____ Date _____

Binary Numbers (A)

This is a short test to determine whether you have any knowledge of binary numbers.

1. Complete the series of binary numbers by filling in the blanks.

   a) 1, 10, ____
   b) 100, 101, ____

2. What binary number is equivalent to the decimal number 8?

   _____

3. Add the following binary numbers:

   a) 10 + 10 .

   b) 1 + 1

Appendix D
Achievement Test

Name _____

Examination: Binary Numbers (B)

I. Binary Addition:

1) 1 + 1 + 1 = ____

2) 11 + 1 + 1 = ____

3) 1111 + 1001 + 1100 = ____

4) 1011 + 1101 + 1110 + 1001 = ____

5) 111 + 111 = ____

6) 111 + 011 + 111 + 111 = ____

7) 111 + 101 + 110 + 111 = ____

II. Binary Subtraction:

8) 100 - 10 = ____

9) 1000 - 111 = ____

10) 10101 - 1100 = ____

11) 1010 - 111 = ____

12) 11000 - 101 = ____

13) 110100 - 11001 = ____

14) 101 - 11 = ____

III.

15) Using a quaternary system, write the quaternary number that would represent the same quantity as does the decimal number 18. _____

16) Write the quaternary number that represents the same quantity as does the binary number 111. _____

IV. Following is a series of problems involving addition and subtraction in the quaternary system. All the problems are written in quaternary numbers and you are to write your answer in quaternary numbers.

Quaternary Addition:

17) 21 + 22 = ____

18) 12 + 12 = ____

19) 12 + 33 = ____

Quaternary Subtraction:

20) 21 - 3 = ____

Appendix D

Attitude Questionnaire

Binary Numbers

Name_____
Date_____

Questionnaire

1. Estimate the number of errors you think you made in going through the program (not including the examination). Encircle the closest estimate.

   a) less than 5
   b) between 5 and 10
   c) between 10 and 20
   d) between 20 and 30
   e) between 30 and 40
   f) between 40 and 50
   g) between 50 and 60
   h) more than 60

2. Rate the ease or difficulty of the program using the five point scale below. A rating of 1 would indicate very easy; while a rating of 5 would indicate very difficult. Place a check mark in the box indicating your rating.

Very Easy	Easy	Slightly Difficult	Difficult	Very Difficult
1	2	3	4	5

3. Did you find the program interesting?

4. Would you like to study other subjects this way?

Appendix D

Speed Test

1) 1 plus 11

2) 11 plus 10

3) 100 plus 101

4) 111 plus 111

5) 100 minus 11

6) 11 minus 10

7) 111 minus 101

8) Give the binary equivalent for the decimal number 9

Appendix D
Retention Test

Name _____ Date _____

Binary Numbers (C)

I. Complete the following counting sequences in binary numbers:

a) 1, 10, 11, ____, ____

b) 1111, _____

II. Binary Addition

1) 1 + 1 + 1 = ___ 2) 11 + 1 + 1 = ___ 3) 111 + 111 = ___ 4) 1111 + 1001 + 1100 = ___ 5) 1011 + 1101 + 1110 + 1001 = ___

6) 111 + 101 + 110 + 111 = ___ 7) 111 + 011 + 111 + 111 = ___

III. Binary Subtraction

8) 101 - 11 = ___ 9) 100 - 10 = ___ 10) 10101 - 1100 = ___ 11) 1010 - 111 = ___

12) 11000 - 101 = ___ 13) 110100 - 11001 = ___ 4) 1000 - 111 = ___

IV.

15) Write the quaternary number for the decimal number 18. _____

16) Write the quaternary number for the binary number 111. _____

V. Below is a series of problems involving quaternary numbers. All the problems are given in quaternary numbers and you are to write your answers in quaternary numbers.

Quaternary Addition:

17) 21 + 22 = ___ 18) 12 + 12 = ___ 19) 12 + 33 = ___

Quaternary Subtraction:

20) 21 - 3 = ___